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Oliver

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(54) **GIMBAL OPTICAL SYSTEM FOR DOCUMENT IMAGE CAPTURE**

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(52) **U.S. Cl.** **348/375**; 348/335
(58) **Field of Search** 348/207.99, 220.1, 348/208.11, 335, 373, 374, 375, 376, 151; 250/208.1; 396/427; 482/79

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,131,919	A		12/1978	Lloyd et al.	
4,420,773	A		12/1983	Toyoda et al.	
4,541,010	A		9/1985	Alston	
4,788,596	A	*	11/1988	Kawakami et al.	348/208.11
5,153,623	A	*	10/1992	Bouvier	396/427
5,394,184	A	*	2/1995	Anderson et al.	348/151
5,520,598	A	*	5/1996	Little	482/79

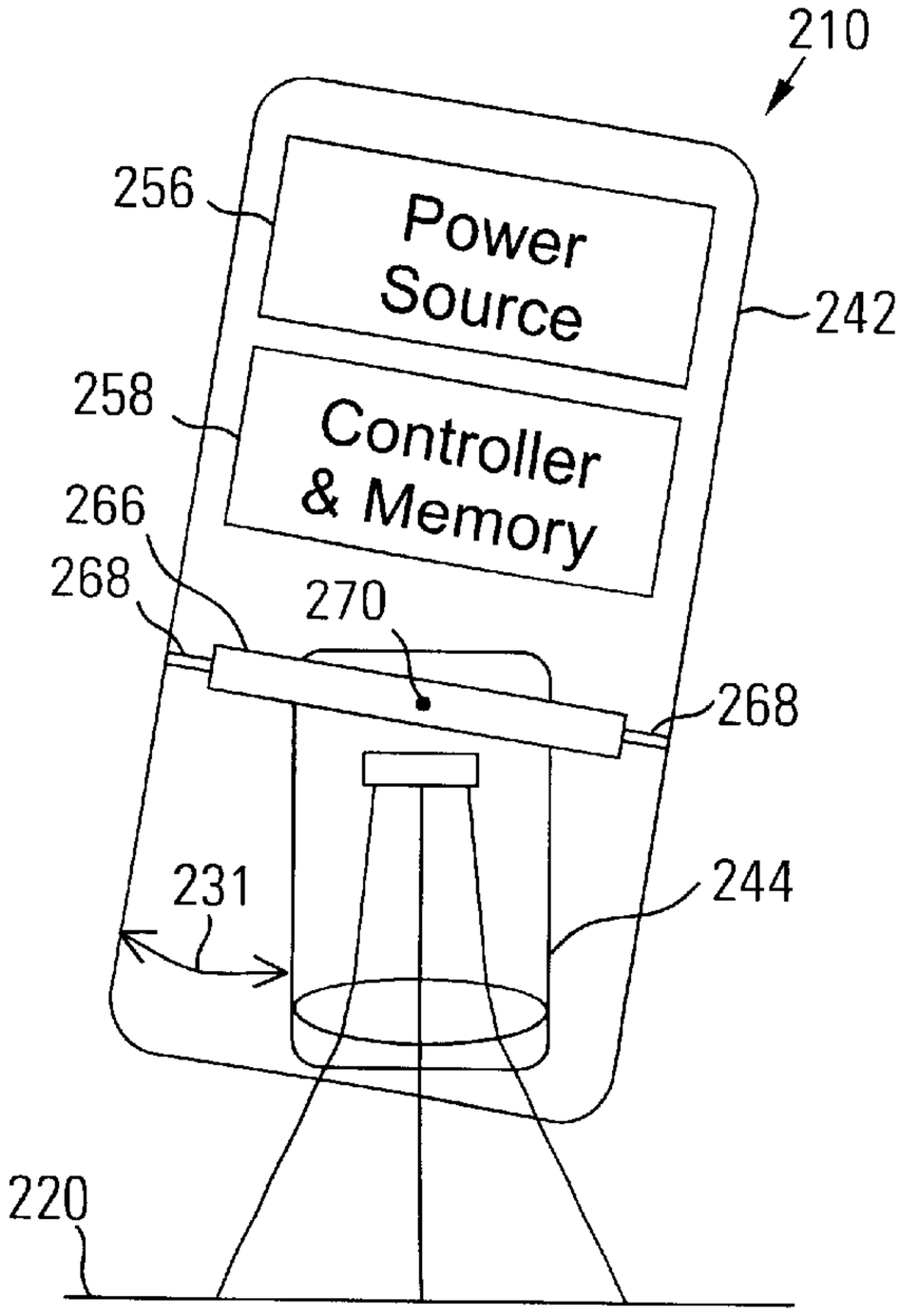
* cited by examiner

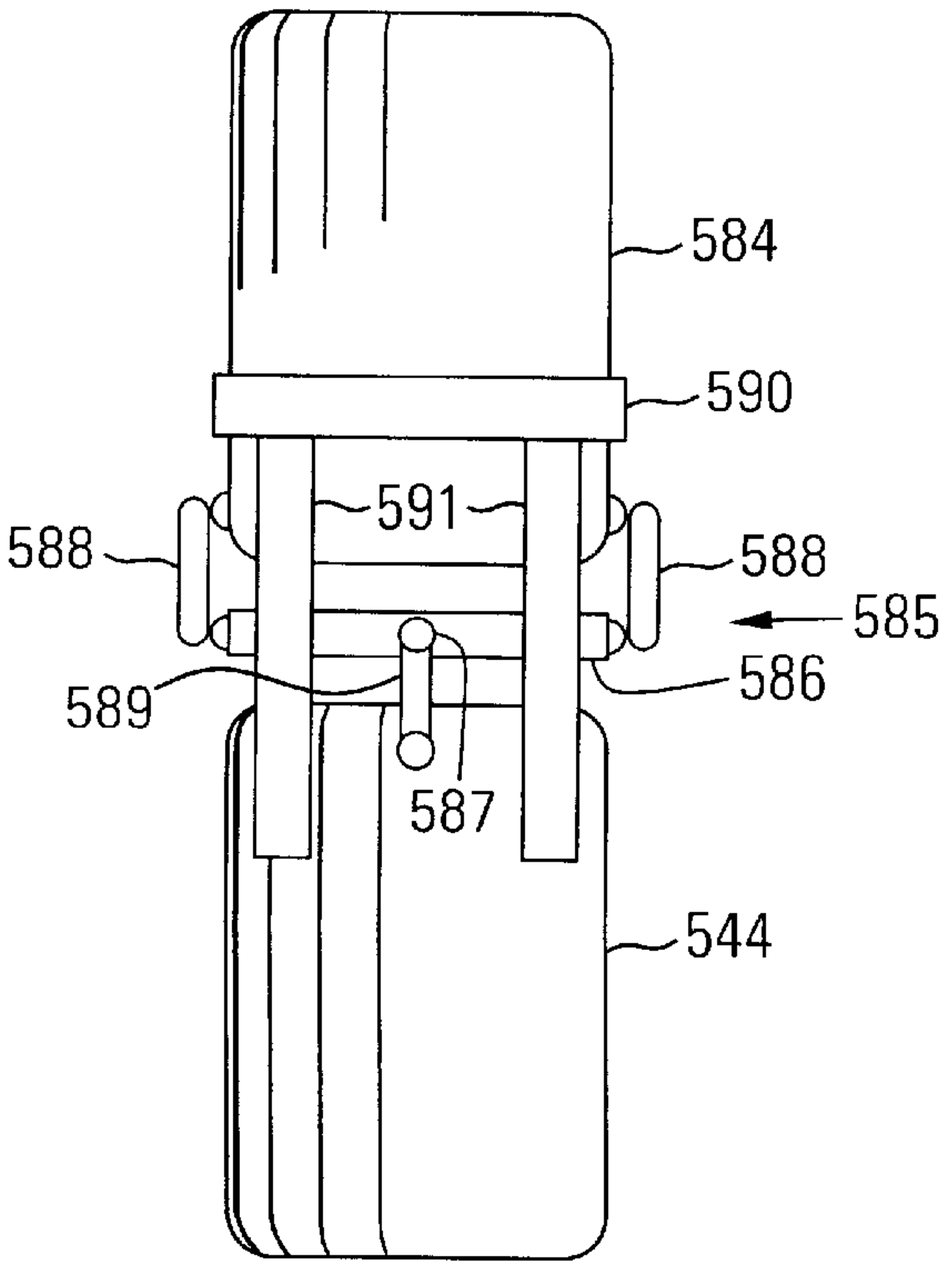
Primary Examiner—Tuan Ho

(57) **ABSTRACT**

An imaging device for document imaging may comprise a housing and an optical system having a lens system and an optical detector. The optical system is responsive to image light reflected by an object and produces image data representative of the image light. The optical system is pivotally mounted to said housing and is biased toward a vertical orientation inside said housing by gravity.

2 Claims, 6 Drawing Sheets





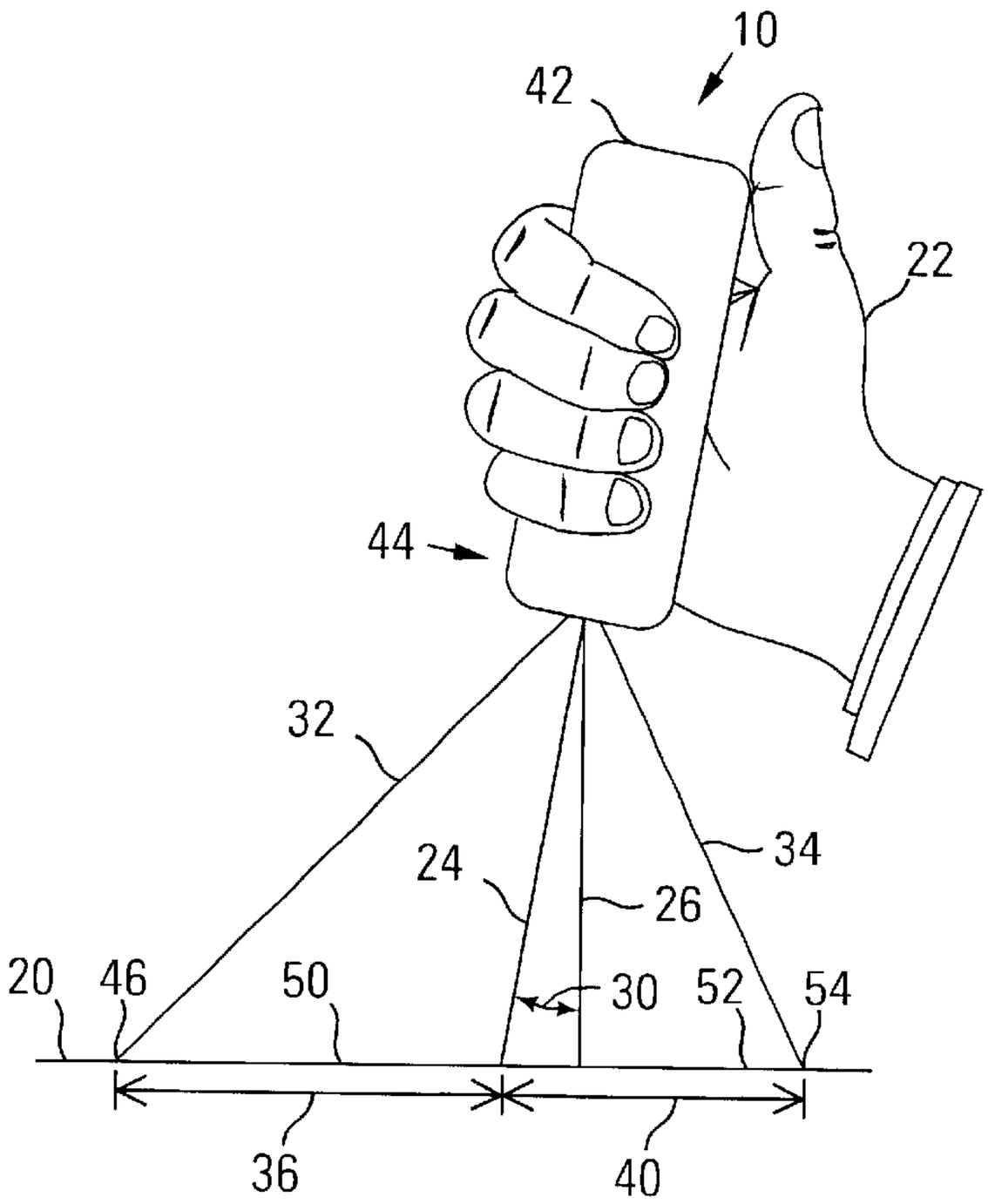

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FIG. 1

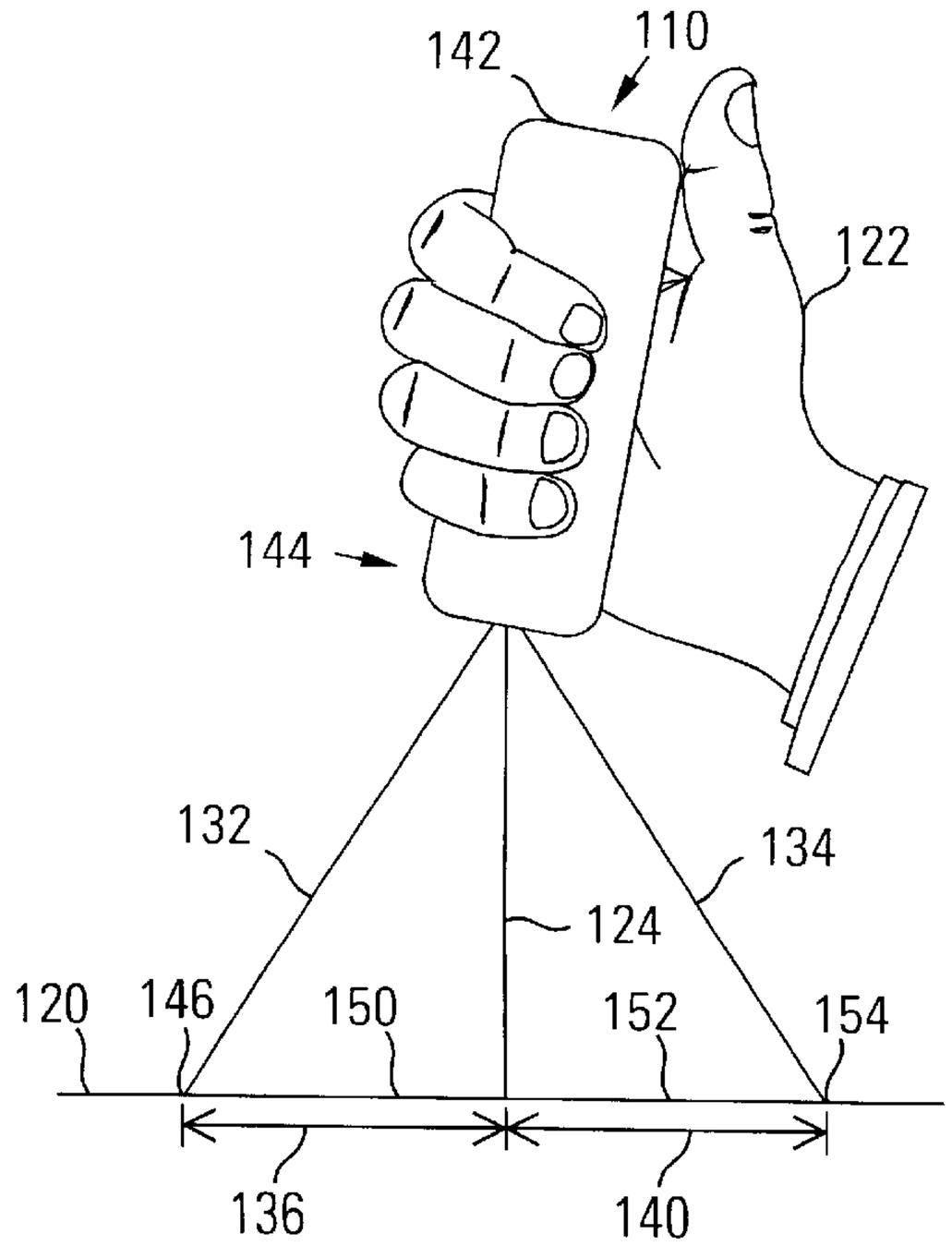
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FIG. 2

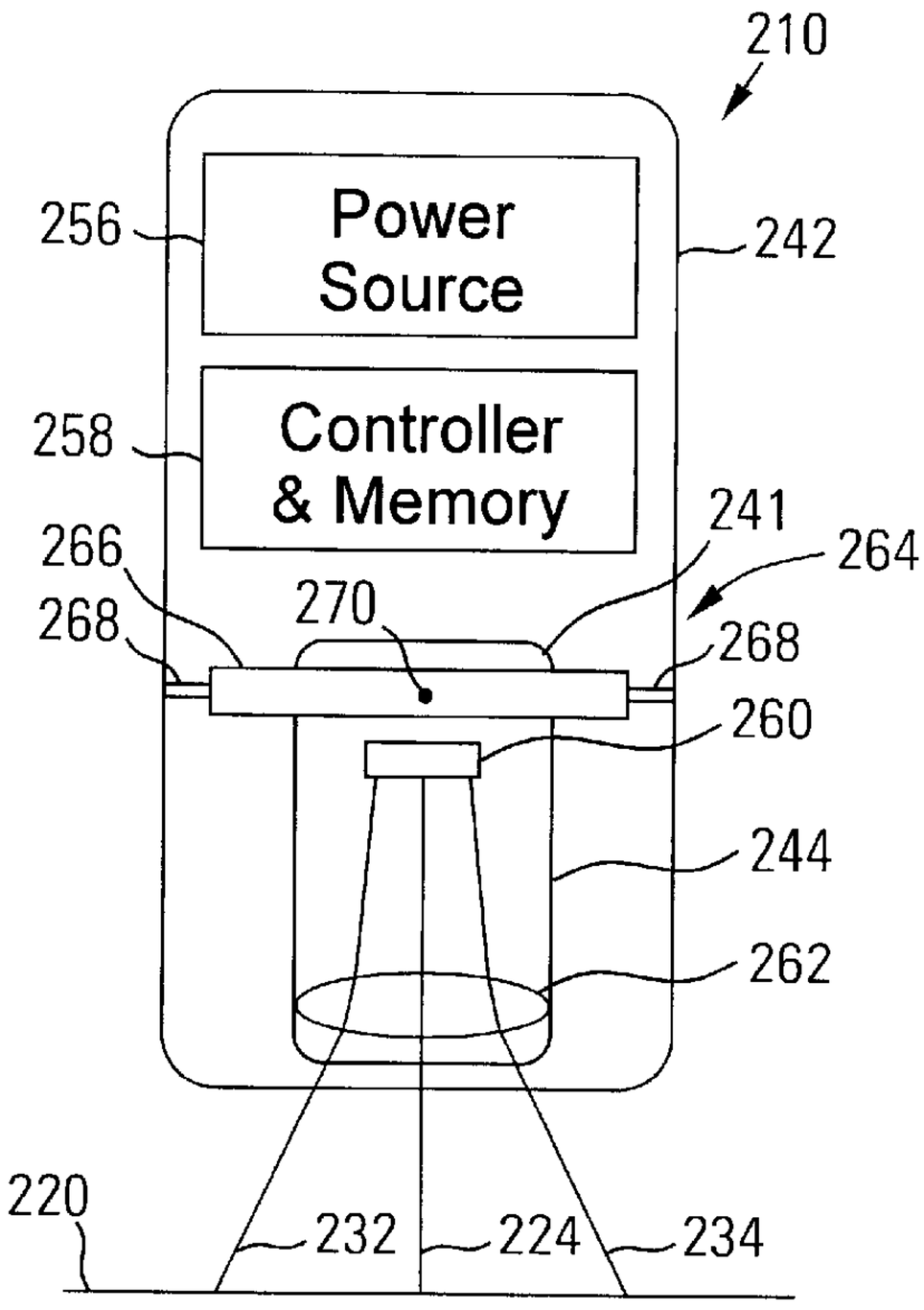
210
256
Power Source
242
258
Controller & Memory
241
264
266
268
270
268
260
244
262
220
232
224
234

FIG. 3

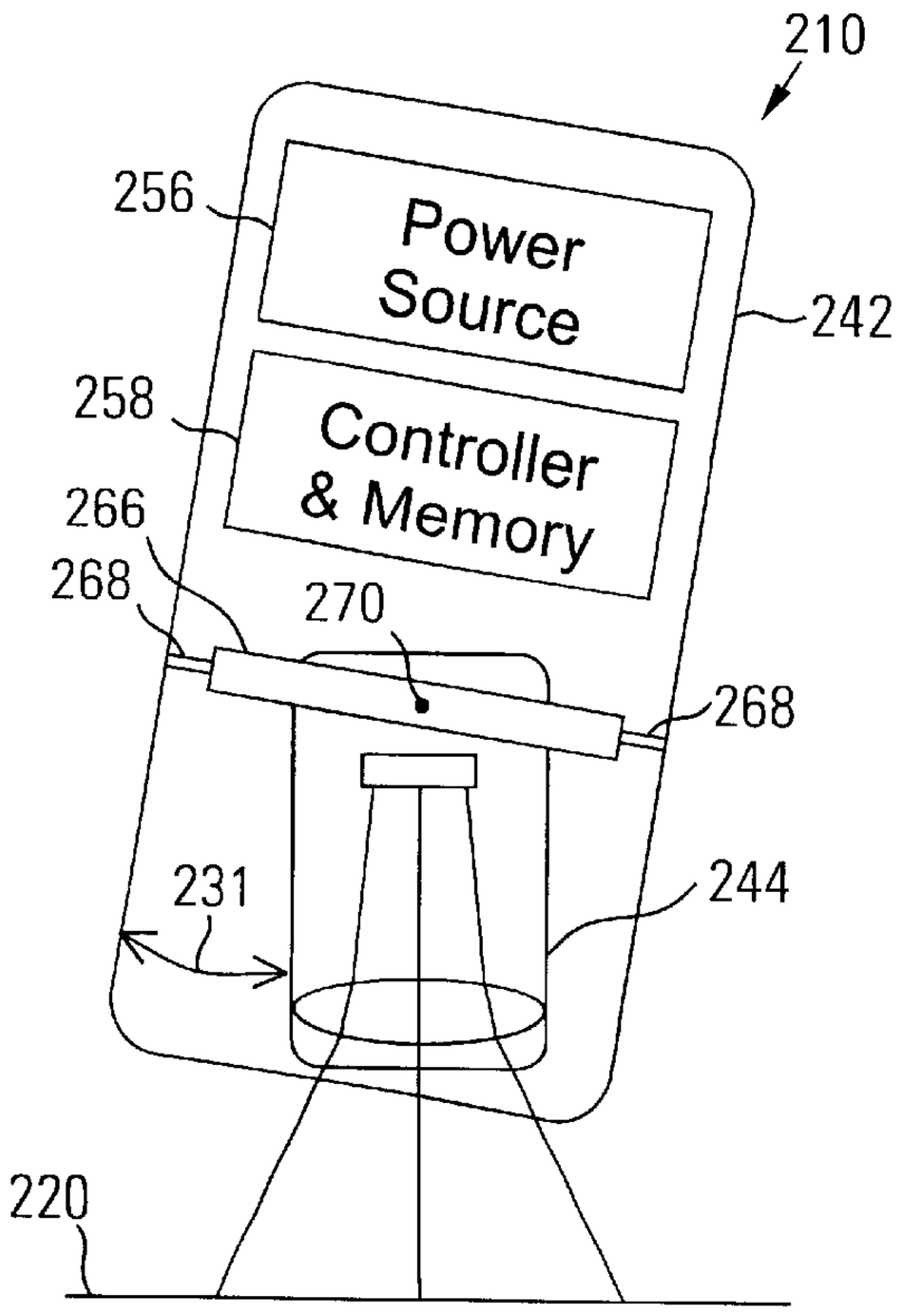
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FIG. 4

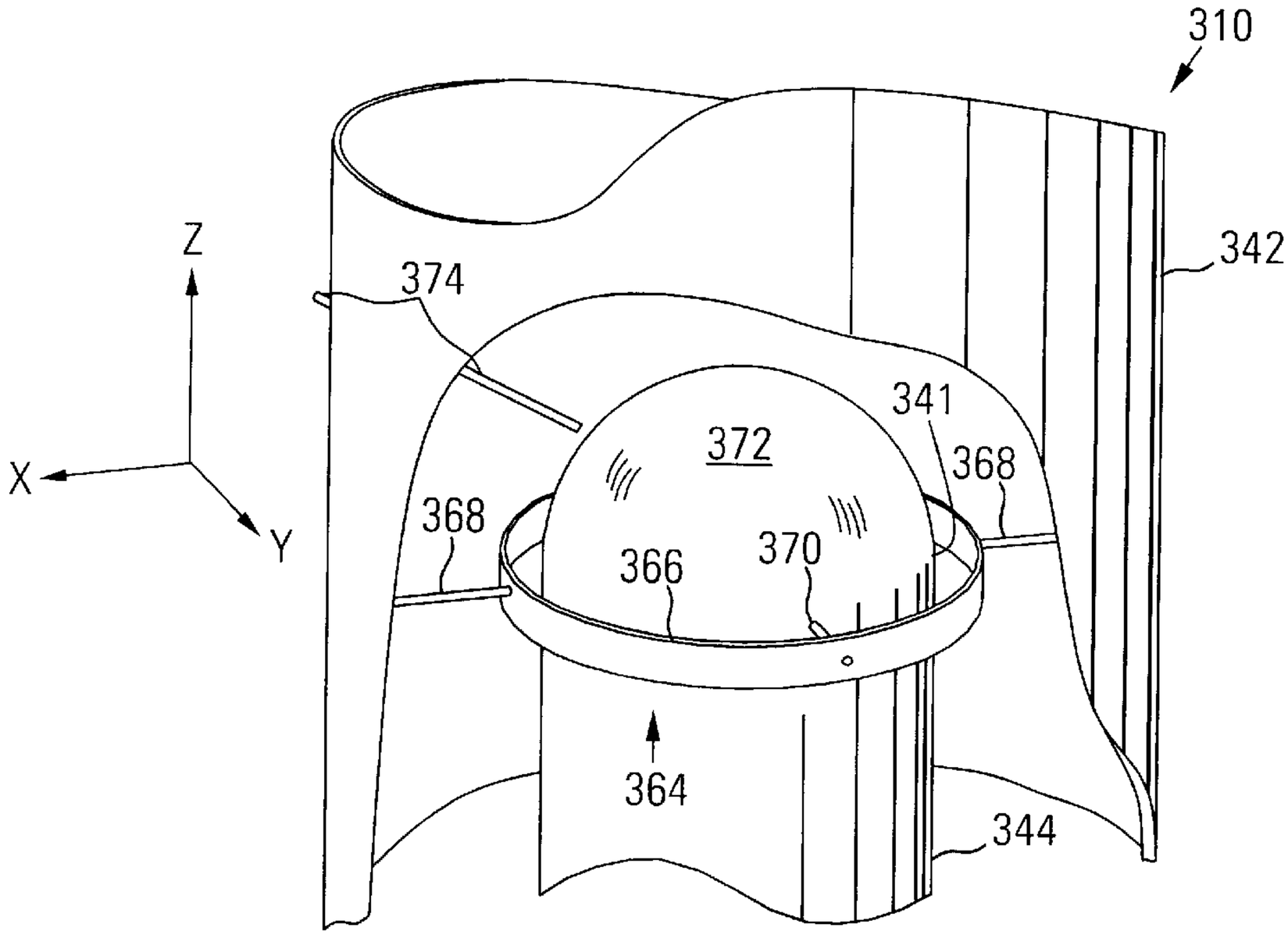


FIG. 5

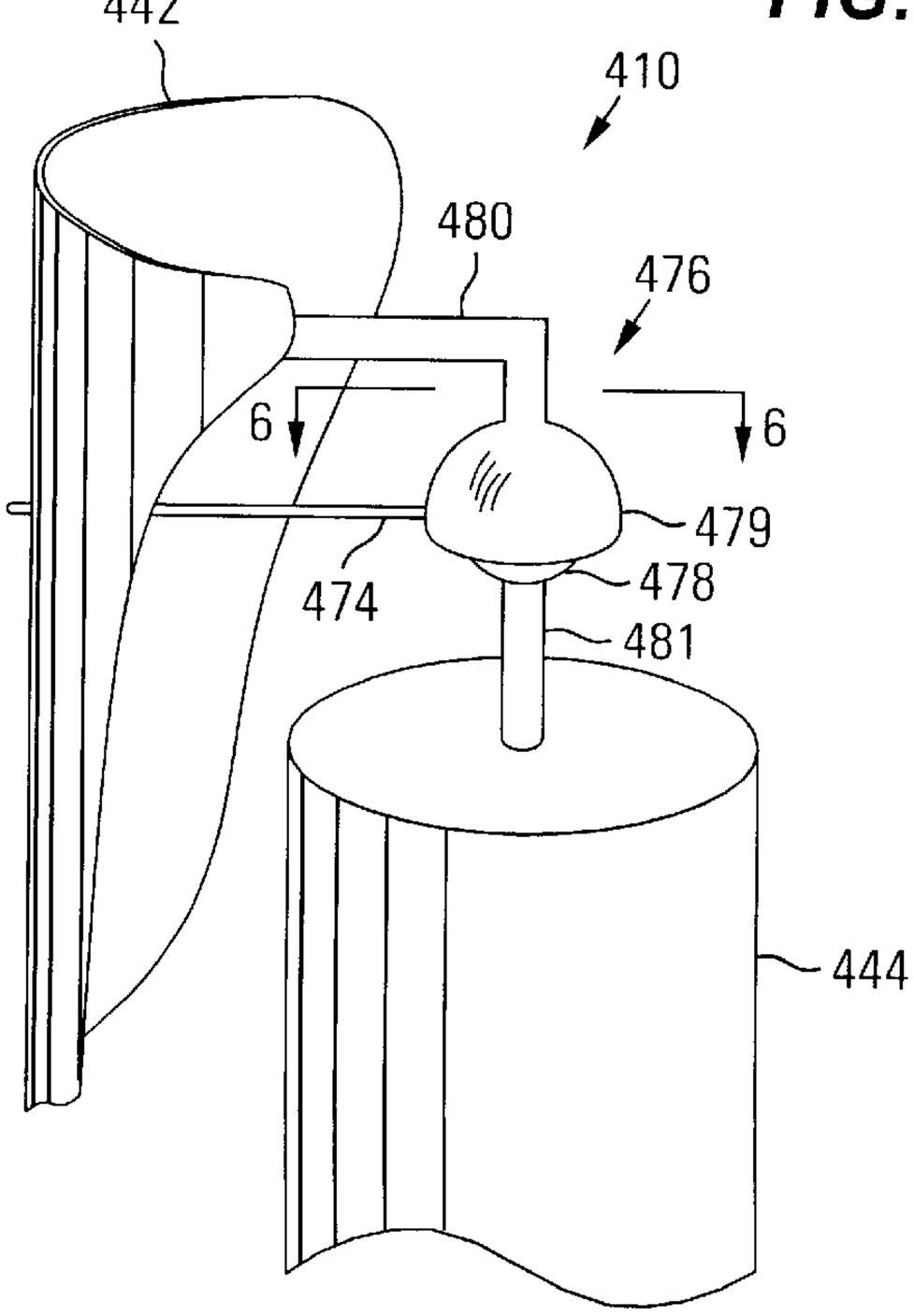


FIG. 6

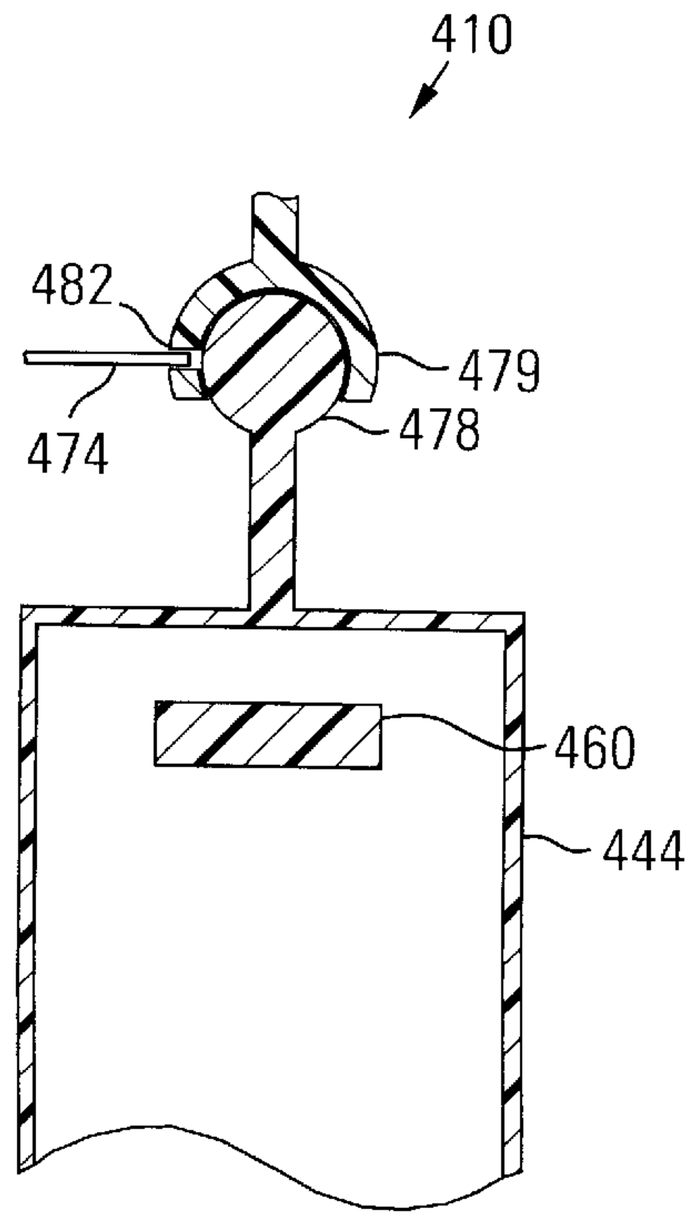


FIG. 7

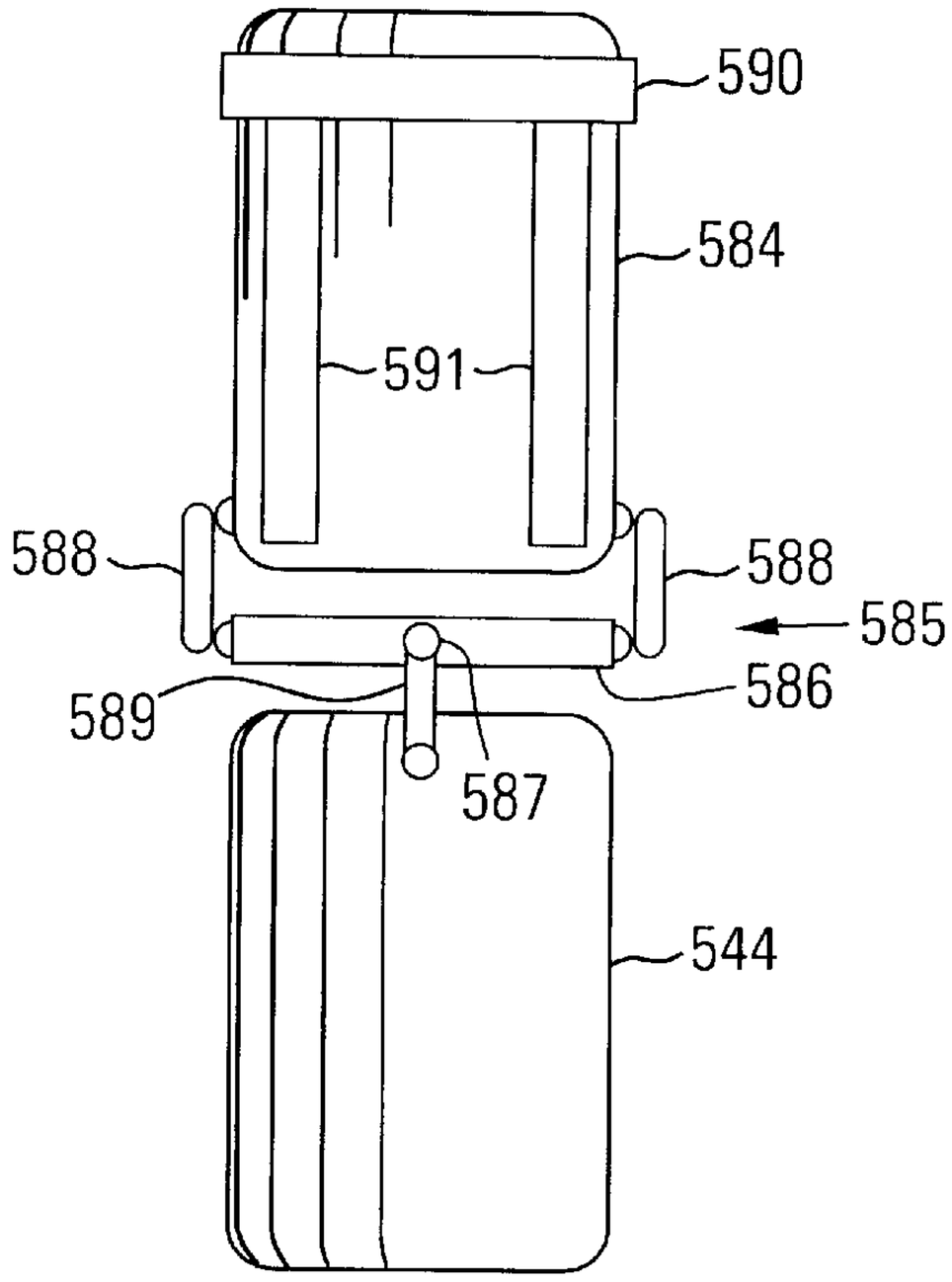


FIG. 8

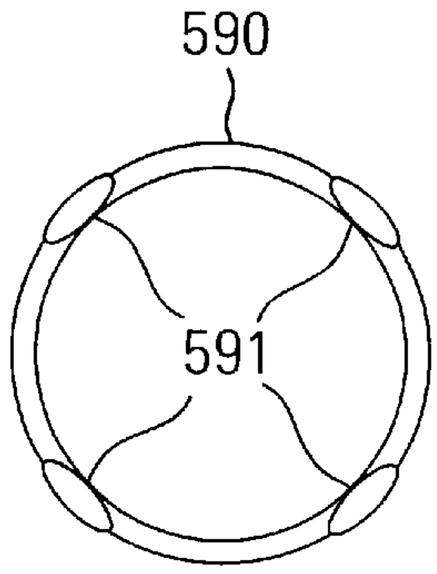


FIG. 10

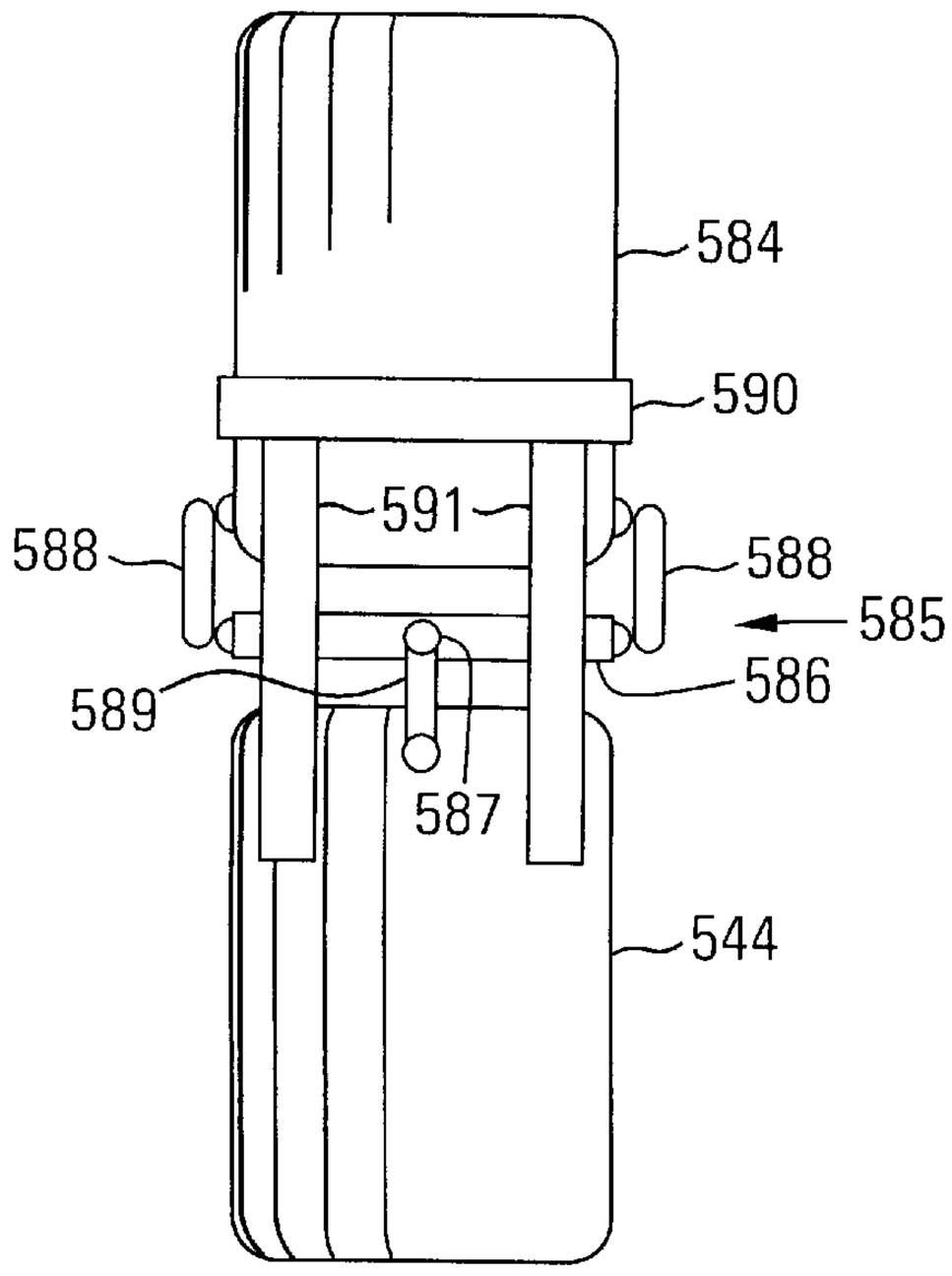
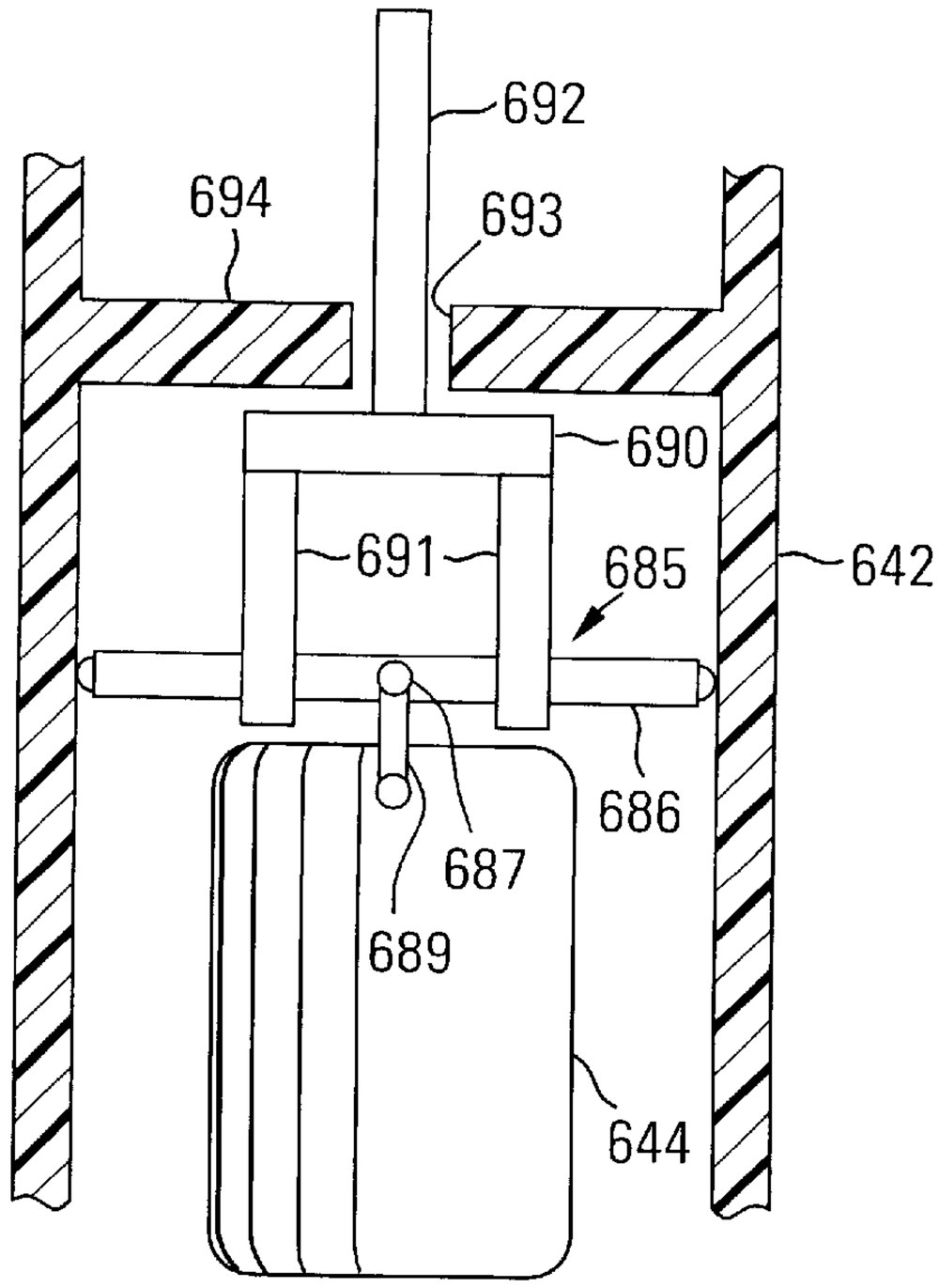


FIG. 9


692
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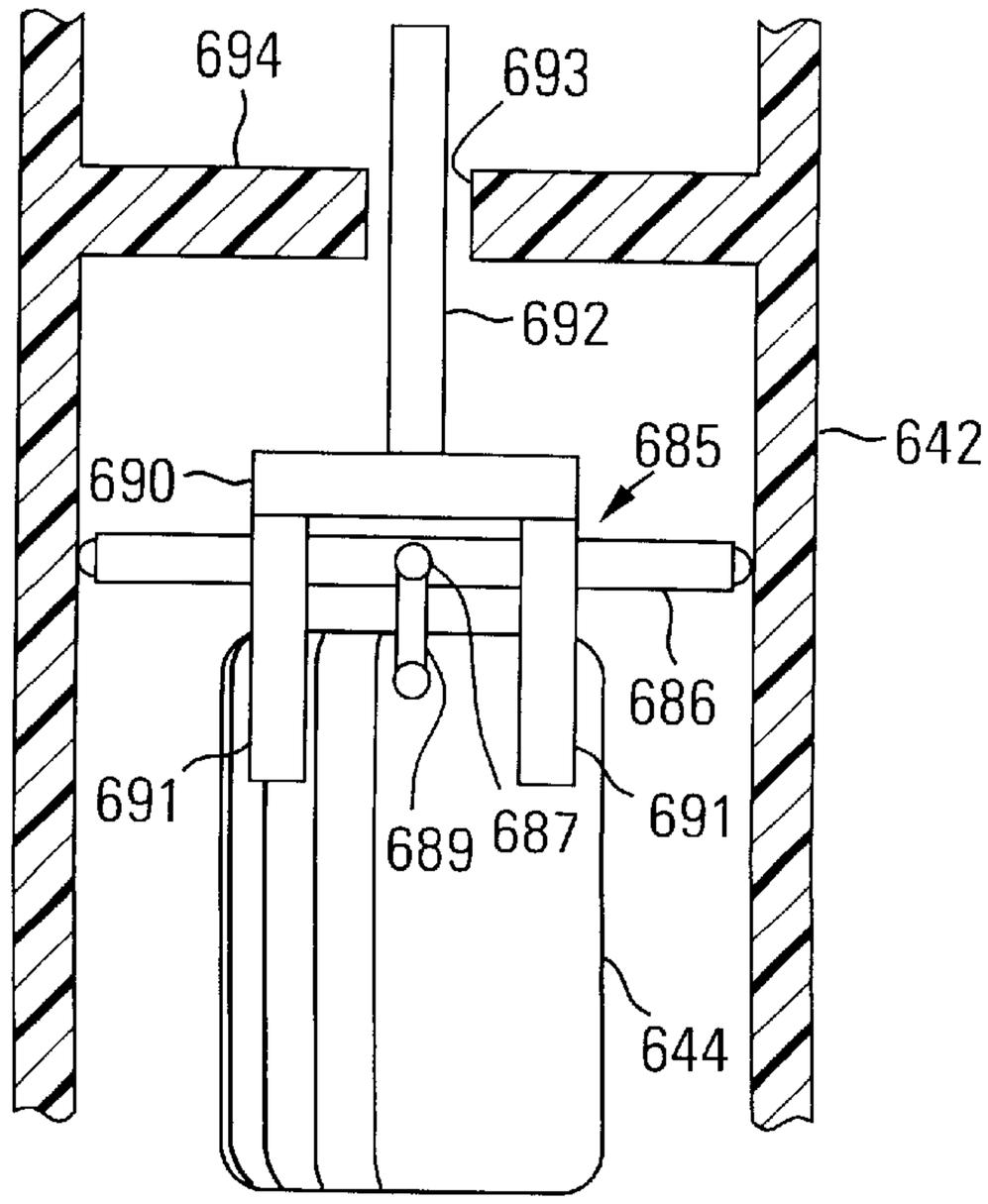
644

FIG. 11


694
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642
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644

FIG. 12

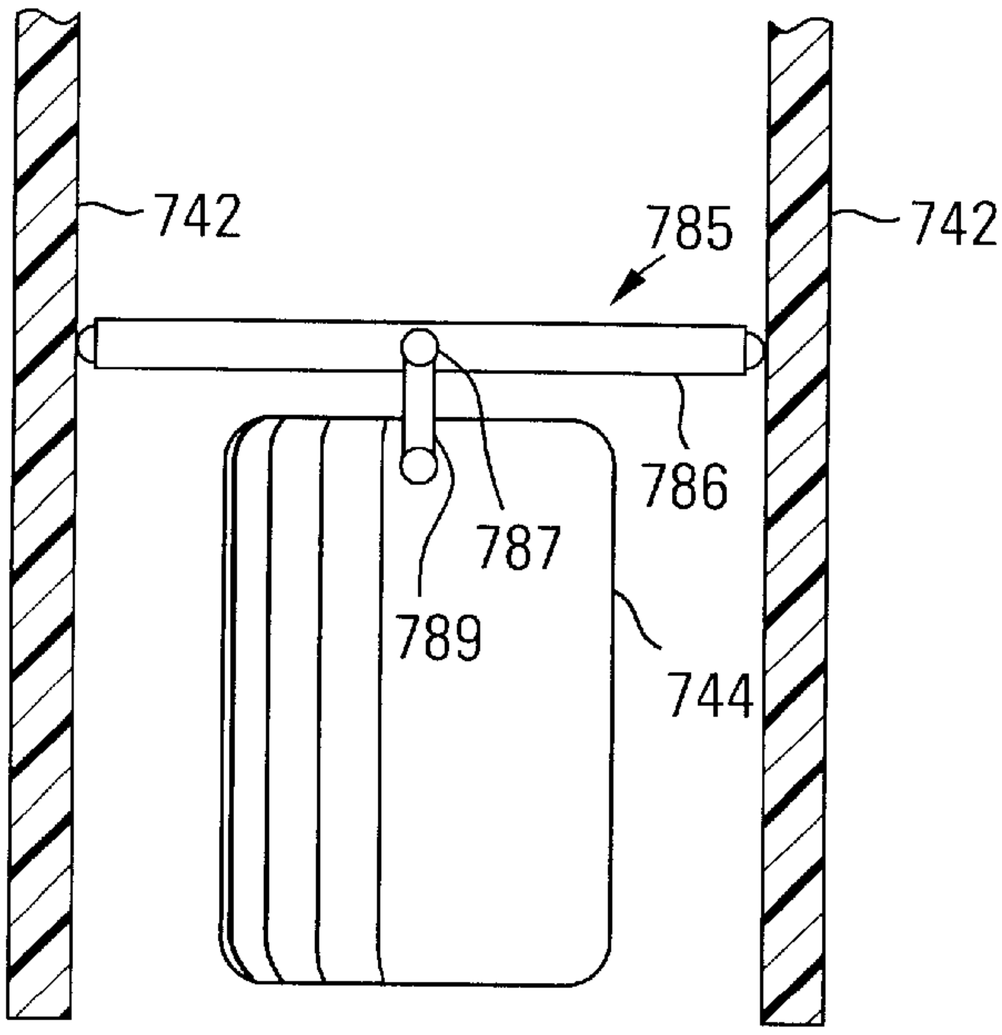

FIG. 13

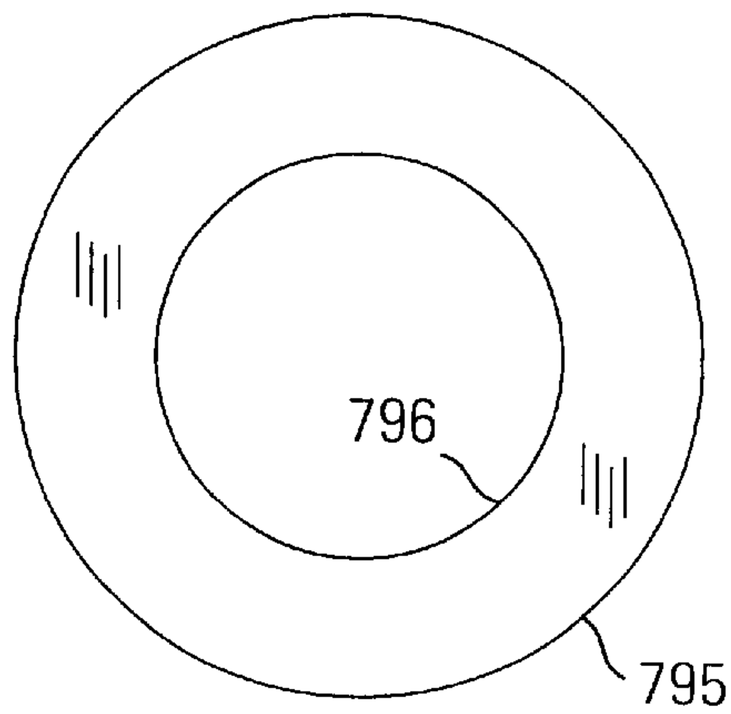

FIG. 15

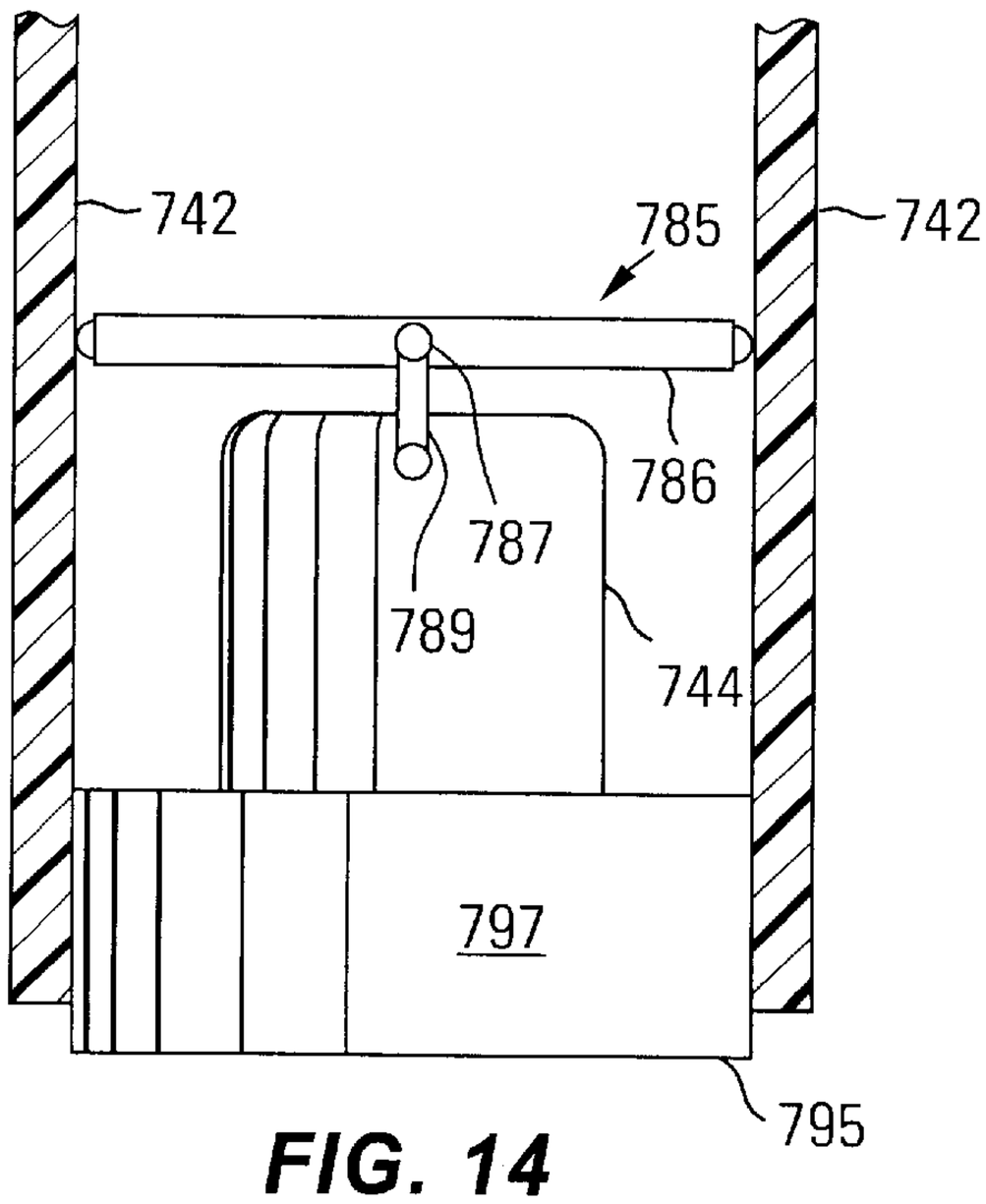

FIG. 14

GIMBAL OPTICAL SYSTEM FOR DOCUMENT IMAGE CAPTURE

FIELD OF THE INVENTION

The present invention relates generally to the field of document imaging, and more particularly, to a system and method for vertically orienting an optical path in a digital camera.

BACKGROUND OF THE INVENTION

Imaging devices such as optical cameras and scanners are well known in the art and may be used to quickly and easily capture the image of a document for numerous applications. The images may be processed and stored either chemically on photographic paper, or electronically in the form of electrical signals, either analog or digital. As computer use becomes more prevalent, document imaging is becoming more important and widespread. In a typical digital camera or scanner application, the image data signals produced by the camera or scanner may be used by a personal computer to reproduce an image of the object on a suitable display device, such as a CRT or a printer.

A hand-held or portable digital camera is a digital camera which is designed to be hand held and pointed at the object or document being imaged. A hand-held or portable optical scanner is an optical scanner which is designed to be moved by hand across the object or document being scanned. The imaging device, either digital camera or scanner, may be connected directly to a separate computer either by a data cable or wireless data link. If so, the data signals produced by the imaging device may be transferred to the separate computer "on the fly," i.e., as the image data are collected. Alternatively, the imaging device may include an on-board data storage system for storing the image data. The image data may then be downloaded to a separate computer after the scanning operation is complete by any convenient means, such as via a cable or an optical infrared data link.

Digital cameras are well-known in the art and various components thereof are described in U.S. Patent application, Ser. No. 09/189/128, for TWO PIECE SYSTEM FOR DOCUMENT IMAGE CAPTURE of Thomas C. Oliver, U.S. Patent application, Ser. No. 09/295,865, for DIGITAL CAMERA WITH INERTIAL POSITION SENSING of David D. Bohn U.S. Pat. No. 4,131,919, U.S. Pat. No. 4,420,773, and U.S. Pat. No. 4,541,010, all of which are hereby incorporated by reference for all that they disclose.

A typical hand-held digital camera or optical scanner may include illumination and optical systems to accomplish imaging of the object. The illumination system illuminates all or a portion of the object, whereas the optical system collects light reflected by the illuminated target region and focuses the reflected light onto the surface of a photosensitive detector positioned within the imaging device. By way of example, the illumination system may include a light source (e.g., a fluorescent or incandescent lamp or an array of light emitting diodes (LEDs)). The optical system may include a lens and/or mirror assembly to direct and focus the image of the illuminated target region along the optical axis of the optical system onto the surface of the detector.

The photosensitive detector used to detect the image light focused thereon by the optical system may be a charge-coupled device (CCD), although other devices may be used. A typical CCD may comprise an array of individual cells or "pixels," each of which collects or builds-up an electrical charge in response to exposure to light. Since the quantity of the accumulated electrical charge in any given cell or pixel is related to the intensity and duration of the light exposure, a CCD may be used to detect light and dark spots on an image focused thereon.

The term "image light" as used herein refers to the light that is focused onto the surface of the detector array by the optical system. The image light may be converted into digital signals in essentially three steps. First, each pixel in the CCD detector converts the light it receives into an electric charge. Second, the charges from the pixels are converted into analog voltages by an analog amplifier. Finally, the analog voltages are digitized by an analog-to-digital (A/D) converter. The digital data then may be processed and/or stored as desired.

Portable imaging devices of the type described above are not without their problems. For example, when a portable imaging device is positioned over a document, it is difficult, if not impossible, to perfectly orient the imaging device by hand so that the optical axis is perpendicular to the document. The task is easier with portable scanners which may comprise a flat base to hold against the document. However, as portable scanners become smaller, their bases become increasingly narrow and correct orientation becomes more difficult.

If the imaging device is not held with the optical axis perpendicular to the document face, the resulting image of the document will be stretched and may be blurry and illegible. When the imaging device is not perpendicular, (i.e., is held at an angle other than 90° to the document face), one area of the document is closer to the imaging device's photosensitive detector than the other. Portions of the document which are closer to the imaging device will appear larger, or zoomed in, in the final image. Portions of the document which are farther from the imaging device will appear smaller, or zoomed out, in the final image. The image will also appear compressed along an axis between the closer area and the more distant area. For example, a circle on the document would appear elliptical, or a square on the document would appear rectangular or trapezoidal in the resulting image. Finally, depending upon the depth of field of the imaging device's optical system, portions of the final image may be out of focus.

Digital cameras may be held in place over a document with a fixture such as a tripod or bracket to help hold them in a given orientation. However, it is difficult to properly orient a digital camera even when held in such a fixture if the fixture allows for angular adjustment, as most common tripods do. Some tripods include an air bubble tilt meter, but bubble meters are not very accurate and offer no feedback for large angles when the bubble moves beyond the viewable window. Furthermore, the usefulness and portability of a digital camera requiring a tripod or fixture for document imaging is greatly limited.

A need therefore exists for a system to automatically maintain a vertical orientation of the optical axis in an imaging device, perpendicular to a document positioned below the imaging device. A need further exists for a system allowing the imaging device to be used in non-vertical applications as well as document imaging.

SUMMARY

To assist in achieving the aforementioned needs, the inventor has devised an electronic imaging device having an optical assembly pivotally mounted therein. The pivot mount allows the optical assembly to be pulled by gravity into a vertical orientation over a document. This improves

image quality by aligning the optical axis of the optical assembly perpendicularly with respect to the document, preventing image distortion.

An imaging device for document imaging having features of the present invention may comprise a housing and an optical system having a lens system and an optical detector. The optical system is responsive to image light reflected by an object and produces image data representative of the image light. The optical system is pivotally mounted to said housing and is biased toward a vertical orientation inside said housing by gravity.

The invention may also comprise an electronic imaging assembly comprising a body portion, an imaging means for focusing, directing, and sensing image light, and a mounting means. The first means is pivotally mounting to the body portion by the mounting means so that the imaging means may be pulled by gravity around the mounting means to vertically orient an optical axis of the imaging means.

The invention may also comprise a digital camera comprising a body portion, a gimbal mounted to the body portion, and an optical system mounted in the gimbal so that the optical system is free to pivot under the force of gravity in the body portion.

The invention may also comprise an imaging device for document imaging, comprising a body portion, an optical assembly, and a pivotal mounting bracket, whereby the optical assembly is pivotally mounted to the body portion. The imaging device also comprises a lock having a locked position and an unlocked position. The optical assembly may be locked into place relative to the body portion when the lock is in the locked position. The optical assembly may pivot about the pivotal mounting bracket when the lock is in the unlocked position.

BRIEF DESCRIPTION OF THE DRAWINGS

Illustrative and presently preferred embodiments of the invention are shown in the drawing, in which:

FIG. **1** is a front view of a digital camera as it may be used for document imaging, having a tilted orientation;

FIG. **2** is a front view of the digital camera of FIG. **1** wherein the image light optical axis has a vertical orientation;

FIG. **3** is a diagram of a digital camera as it may be used for document imaging;

FIG. **4** is a diagram of the digital camera of FIG. **2** having a tilted orientation;

FIG. **5** is a perspective cutaway view of a digital camera showing a gimbal mounted optical system with a friction lock;

FIG. **6** is a perspective cutaway view of a digital camera showing a ball and socket mounted optical system;

FIG. **7** is a cross-sectional view of the digital camera of FIG. **5**;

FIG. **8** is a front view of a gimbal mounted optical system with a ring and finger lock assembly in the unlocked position;

FIG. **9** is a front view of the gimbal mounted optical system of FIG. **7** with the ring and finger lock assembly in the locked position;

FIG. **10** is a bottom view of the ring and finger lock assembly of FIG. **7**;

FIG. **11** is a front view of a gimbal mounted optical system with a plunger lock assembly in the unlocked position;

FIG. **12** is a front view of the gimbal mounted optical system of FIG. **10** with the plunger lock assembly in the locked position;

FIG. **13** is a front view of a gimbal mounted optical system;

FIG. **14** is a front view of the gimbal mounted optical system of FIG. **12** with a locking ring cap attached; and

FIG. **15** is a bottom view of the locking ring cap of FIG. **13**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An electronic imaging device **10** may be used to detect and store the image of an object in electrical form. Typical types of electronic imaging devices include digital cameras and scanners. As digital cameras and scanners have become more portable and computers have become more widely used, document imaging has developed into a very useful tool. A document **20** which may contain both text and graphics may be electronically photographed or scanned, and the resulting image transferred to a computer, manipulated, combined with other documents or information, and printed or transferred across networks to computers across the world. Text contained in an electronic image can also be converted from graphical form to a text file by optical character recognition (OCR) software, allowing the text to be easily edited or manipulated.

Flat bed image scanners may be used to easily scan an entire document in one pass, but are typically large, desk bound machines which are not easily portable. Smaller portable hand-held scanners have become more prevalent, allowing a near-pocket size device to scan a document in multiple passes which are then stitched together to form a single image file representing the entire document.

Digital cameras are well-known in the art and are analogous to ordinary film-type cameras, except that the film is replaced with an electronic photosensor (e.g., a two-dimensional CCD array). The electronic photosensor array converts the light received by the camera into electronic signals, which may be digitized and stored as digital image data. For example, the resulting digital image data may be stored in an electronic memory system, such as random access memory (RAM), or may be stored on a magnetic or optical disk of the type commonly used to store digital data.

Digital cameras offer considerable advantages over conventional film-type cameras in that the digital image data may be stored, processed, and/or reproduced with ease. The relative ease of handling and processing the digital image data produced by digital cameras allows users to readily enlarge, reduce, or otherwise modify the digital image data to create any of a wide range of photographic effects and styles, as well as to easily capture the image of a document and convert text in the image to a text file.

However, digital cameras and portable scanners do have disadvantages. As they become smaller, more portable, and easier to use, it becomes increasingly more difficult to properly align them over the document. If the imaging device is tilted with respect to the document, the resulting image is distorted and OCR software is less effective at recognizing and converting text in the image. Digital cameras held in the air over a document are particularly difficult to align perpendicularly with a document. Portable scanners are somewhat easier to align, since they may be placed against the document. However, the scan head of a portable scanner may be several inches long but only about an inch wide, allowing the portable scanner to rock back or forth

during the scanning motion. This causes the optical axis of the scanner to tilt with respect to the document which may distort the final image.

An exemplary imaging device **10** is illustrated in FIG. **1** as it may be used in document imaging. The imaging device may comprise any type of electronic imaging device which may be used for document imaging, such As a portable scanner. The exemplary embodiment of an imaging device **10** illustrated in FIG. **1** comprises a digital camera.

The imaging device **10** illustrated in FIG. **1** is held over an object, such as a document **20**, in the hand **22** of a user. The user has positioned the imaging device **10** but has oriented it at an angle with respect to the document **20**. Image light (e.g., **32** and **34**) is reflected from the document **20** into the optical system **44** of the imaging device **10**.

The optical axis **24** of the imaging device **10** is aligned normally with the housing or body portion **42** of the imaging device **10**, i.e., the housing **42** and the optical system **44** are tilted together at the same angle **30**. In contrast, the optical axis **124** of the imaging device **110** illustrated in FIG. **2** has been vertically oriented to prevent distortion of the resulting document image.

The tilted optical axis **24** shown in FIG. **1** illustrates the normal operation of a typical digital camera when it is improperly oriented, or the operation of an imaging device **10** according to a presently preferred embodiment having a locking device in place to secure the optical system **44** to the housing **42**, as will be described in more detail hereinafter.

The image light **32** reflected to the optical system **44** from the area **50** between the left side **46** of the target region and the optical axis **24** will form the left half of the resulting document image (not shown). The image light **34** reflected to the optical system **44** from the area **52** between the right side **54** of the target region and the optical axis **24** will form the right half of the resulting document image. The imaging device **10** shown in FIG. **1** is tilted in the users hand **22**, causing the optical axis **24** to form a non-zero angle **30** with respect to the vertical axis **26** which is perpendicular to the document **20**. As a result of this non-zero angle **30**, the left area **50** has a width **36** which is greater than the width **40** of the right area **52**. In the resulting document image, the left area **50** and the right area **52** will appear as the same size, each forming half of the final image. The tilted imaging device **10** will compress the larger left area **50** into the same space in the final image as the smaller right area **52**. Therefore, text or images nearer the left side **46** of the document **20** will appear smaller, or compressed, when compared with text or images nearer the right side **54**.

A preferred embodiment of an imaging device **110** for document imaging having a gimbaled or otherwise pivoting optical system **144** is shown in FIG. **2**. The camera body **142** is held in the users hand **122** over a document **120**. The optical system **144** is mounted to the camera body or housing **142** on a gimbal or other pivoting mounting bracket (not shown), to be described in more detail hereinafter. The mounting bracket allows the optical system **144** to pivot under the force of gravity independent of the tilt angle of the housing **142**, within a range of tilt angles which may be inadvertently caused during normal document imaging operations. The mounting bracket may allow the optical system **144** to pivot either along one or two axes within the camera housing **142** according to various embodiments.

Although the camera housing **142** is tilted and is not held vertical or perpendicular with respect to the document **120**, the optical system **144** is pulled into a vertical orientation by gravity inside the camera housing **142**. When the document **120** is placed on a level, horizontal surface below the imaging device **110**, the optical axis **124** of the pivoted optical system **144** is perpendicular to the document **120**. The resulting document image will therefore be undistorted by the angle of the housing **142**.

The left document area **150** between the left side **146** and the optical axis **124** is reflected in image light **132** on the left side, and the right document area **152** between the right side **154** and the optical axis **124** is reflected in image light **134** on the right side. Since the optical axis **124** is perpendicular to the document, the width **136** of the left area **150** is equal to the width **140** of the right area **152**, and the image of the document **120** will be captured properly, without compression or distortion.

Before describing an imaging device **10** for document imaging having a gimbaled or otherwise pivoting optical system in more detail, an exemplary digital camera and portable scanner which may employ a pivoting optical system will be described. However, it is important to note that the gimbaled or otherwise pivoting optical system may be employed in any imaging device for document imaging, and should not be viewed as limited to the exemplary devices discussed herein.

With the foregoing considerations in mind, a digital camera **210** (FIG. **3**) may comprise a main body portion **242** which is sized to receive the various systems and components required by the digital camera. For example, in the embodiment shown and described herein, the body **210** is sized to receive the optical system **244**, a pivoting optical system mounting bracket **264**, and electronic systems such as a controller and memory **258** to process and store the image data. It is generally preferred, but not required, that the controller and memory **258** of the digital camera **210** include an image processing system to allow the image data collected by the camera to be processed independently, i.e., without having to connect the camera to a separate computer or other such device to process and format the image data. The body **242** may also be sized to receive a power source **256** such as a battery. The digital camera **210** preferably includes an illumination system such as a flash mounted on the outside of the body **210**. Each of the foregoing systems and devices will now be described in detail.

The main body or housing **242** of the digital camera **210** may comprise a generally rectangularly shaped structure sized to receive the various internal components of the camera **210**. For example, in the embodiment shown and described herein, the main body **210** is sized to receive the various electronic components comprising the power source **256**, controller and memory **258**, pivoting mounting bracket **264**, and optical system **244**. The body **210** may also be sized to receive other components, such as a battery system **256** and a portable media mass data storage system **258** (e.g., a magnetic floppy disk drive or an optical disk drive (not shown)) to allow image data produced by the digital camera **210** to be stored on portable media (e.g., a magnetic or optical disk). However, since digital cameras and camera bodies are well-known in the art and could be easily provided by persons having ordinary skill in the art after having become familiar with the teachings of the present invention, the main body **242** utilized in one preferred embodiment of the present invention, as well as the various ancillary systems and devices (e.g., battery systems and media recording systems) that may be utilized in one preferred embodiment of the present invention will not be described in further detail herein.

The optical system **244** may comprise a lens assembly **262** and an image sensor **260**. The lens assembly **262**

collects and focuses on the image sensor **260** image light **232** and **234** reflected by the object or document **220**. The image sensor **260** in turn produces image data (not shown) that are representative of the image light **232** and **234** reflected by the document **220**. The image data (not shown) produced by the image sensor **260** may be directed to the controller and memory **258**.

The lens assembly **262** may comprise any of a wide range of lens assemblies that are well-known in the art and readily commercially available. For example, in one preferred embodiment, the lens assembly **262** may comprise a lens assembly available from Pentax of Japan. The lens assembly **262** may be mounted to the optical system **244** according to any of a wide variety of mounting systems and methods well-known in the art. The image sensor **260** may be mounted to a printed wiring board (not shown) that may be secured within the optical system **244** of camera **210**. The image sensor **260** may comprise a two dimensional photosensor array of the type that is well-known in the art and readily commercially available. Consequently, the present invention should not be regarded as limited to any particular type of image sensor **260**. However, by way of example, in one preferred embodiment, the image sensor **260** may comprise a two dimensional CCD array.

Since optical systems of the type utilized in digital cameras are well-known in the art and readily commercially available, and since a detailed description of the optical system is not required to understand or practice the present invention, the optical system **244** and related components (e.g., lens assembly **262** and image sensor **260**) that may be utilized in one preferred embodiment of the present invention will not be described in further detail herein.

The optical system **244** may be mounted to the interior of the camera body **242** using a pivoting mounting bracket **264**. For example, the pivoting mounting bracket **264** may comprise a gimbal ring **266** mounted to the camera body **242** on two opposite sides by outer mounting pins **268**, while the optical system **244** is mounted inside the gimbal ring **266** on two opposite sides by inner mounting pins **270**. The outer mounting pins **268** and inner mounting pins **270** form two axes at right angles to each other, allowing the gimbal ring **266** to pivot along one axis inside the camera body **242**, and the optical system **244** to pivot along another axis at right angles to the first inside the gimbal ring **266**. As the camera tilts, the optical system **244** may remain in a vertical orientation, since the inner and outer mounting pins **270** and **268** allow the optical system **244** to pivot in all directions.

A flash (not shown) may also be mounted to the exterior surface of the camera body **242** to uniformly illuminate the document **220**. The flash may comprise any suitable illumination device, such as an incandescent bulb.

The gimbaled or otherwise pivoting optical system may also be employed in a portable scanner (not shown). A typical hand-held optical scanner may include illumination and optical systems to accomplish scanning of the object. The illumination system illuminates a portion of the object (commonly referred to as a "scan region"), whereas the optical system collects light reflected by the illuminated scan region and focuses a small area of the illuminated scan region (commonly referred to as a "scan line") onto the surface of a photosensitive detector positioned within the scanner. Image data representative of the entire object then may be obtained by placing the portable scanner against the object and sweeping the scan line across the entire object, usually by moving the hand-held scanner with respect to the object. By way of example, the illumination system may include a light source (e.g., a fluorescent or incandescent lamp or an array of light emitting diodes (LEDs)). The optical system may include a lens and/or mirror assembly to direct and focus the image of the illuminated scan line onto the surface of the detector.

The photosensitive detector used to detect the image light focused thereon by the optical system may be a charge-coupled device (CCD), although other devices may be used.

Although a portable scanner does not capture the entire image of a document simultaneously, the image can be distorted or compressed as with a digital camera if the portable scanner is tilted or rocked back and forth during the scanning operation. By mounting the optical system in a gimbaled or otherwise pivoting mounting bracket, the optical system can be maintained in an orientation perpendicular to the document even when the portable scanner is improperly tilted.

Having generally described a gimbaled optical system as it may be used in a digital camera or a portable scanner, the gimbaled or otherwise pivoting optical system will now be described in more detail.

Referring now primarily to FIGS. **3** and **4**, a presently preferred embodiment of a digital camera **210** may comprise an optical system **244** mounted on a gimbal **264**. The gimbal **264** may comprise a gimbal ring **266** mounted to the camera body **242** on two opposite sides by outer mounting pins **268**, while the optical system **244** is mounted inside the gimbal ring **266** on two opposite sides by inner mounting pins **270**. The outer mounting pins **268** and inner mounting pins **270** form two axes at right angles to each other, allowing the gimbal ring **266** to pivot along one axis inside the camera body **242**, and the optical system **244** to pivot along another axis at right angles to the first inside the gimbal ring **266**. As the camera tilts, the optical system **244** may remain in a vertical orientation, since the inner and outer mounting pins **270** and **268** allow the optical system **244** to pivot in all directions.

The optical system **244** is mounted to the gimbal ring **266** near an upper end **241** of the optical system **244** so that the center of gravity of the optical system **244** lies below the gimbal mounting bracket **264**. This allows the force of gravity to pull the optical system **244** into a vertical orientation, keeping the optical axis **224** perpendicular to the document **220**. As illustrated in FIG. **4**, as the camera body or housing **242** is tilted, the optical system **244** remains vertical, forming a non-zero angle **231** between the optical system **244** and the housing **242** of the camera **210**.

The gimbal **264** may have either one or two pivotable axes. For the preferred embodiment illustrated in FIGS. **3** and **4**, the gimbal **264** has two pivotable axes along the inner and outer mounting pins **270** and **268**, which are located at right angles to each other. If the camera **210** is tilted to the right as shown in FIG. **4**, the housing **242** and gimbal ring **266** tilt, and the optical system **244** remains vertical by pivoting about the inner mounting pins **270** inside the gimbal ring **266**. If the camera **210** were tilted into the page, the housing **242** would tilt, and the gimbal ring **266** and optical system **244** would remain vertical by pivoting together about the outer mounting pins **268**. Normally, the camera **210** will not be tilted along only one of the axes established by the inner and outer mounting pins **270** and **268**, thus the gimbal ring **266** and optical system **244** will pivot about both axes simultaneously to remain vertical.

The digital camera **210** may also comprise a flexible cable (not shown) connecting the image sensor **260** in the optical system **244** to the controller and memory **258** in the housing

242, so that a non-zero angle **231** between the optical system **244** and the housing **242** will not break the connection. The digital camera **210** may also comprise any suitable connection method for transferring image data between the optical system **244** and systems in the housing **242**, such as wireless transmission or rotating electrical connections in the mounting pins **268** and **270**.

The gimbaled or otherwise pivotable mounting bracket (e.g., **264**) may be damped to prevent oscillations during use. For example, the mounting pins **268** and **270** may be tightly mounted so that friction is high enough to allow the desired pivoting action while preventing oscillation. Alternatively, a viscous fluid may be placed between moving parts in the bracket to slow the pivoting action. Any suitable damping means now known or that may be developed in the future may be applied to the bracket as needed, according to the design requirements of the imaging device.

Another embodiment of a gimbal mounted optical system is illustrated in FIG. **5**. A digital camera **310** may comprise a housing **342**, in which an optical system **344** is mounted on a gimbal **364**. A gimbal ring **366** is mounted to the inside of the housing **342** on outer mounting pins **368** which allow the gimbal ring **366** to pivot back and forth around an X axis. The optical system **344** is mounted inside the gimbal ring **366** on inner mounting pins **370** which allow the optical system **344** to pivot back and forth around a Y axis.

The gimbal mounted optical system may also comprise a lock having an unlocked position (shown in FIG. **5**) and a locked position. The lock comprises a locking rod **374** which may be pressed and held against a semi-spherical dome **372** to frictionally hold the optical system **344** in position. When the rod **374** is pressed against the dome **372**, the lock is in the locked position and the optical system **344** is prevented from pivoting. When the rod **374** is retracted from the dome **372**, the lock is in the unlocked position and the optical system may freely pivot about the inner and outer mounting pins **370** and **368** under the pull of gravity. The optical system **344** is mounted in the gimbal **364** at an upper end **341** of the optical system, so that the center of gravity of the optical system lies below the gimbal **364**. The dome **372** is attached to the optical system **344** just above the gimbal **364**. As a result, as the optical system **344** pivots on the gimbal **364**, the surface of the dome **372** slides about like a rotating ball, but does not shift position. The locking rod **374** may therefore contact the dome **372** at the same location, regardless of how the optical system **344** is tilted.

The lock allows the digital camera **310** to be used in non-vertical applications, such as photographing scenery. The lock may be moved into the unlocked position when using the camera **310** for document imaging, allowing the optical system **344** to pivot into a vertical orientation. The lock may then be moved into the locked position, preventing the optical system **344** from pivoting so that the camera **310** may be raised into a horizontal or other orientation.

The optical system **344** and dome **372** may be formed as a single integral unit, with the image sensor (not shown) located in either the optical system **344** or the dome **372**. Alternatively, the optical system **344** and dome **372** may comprise independent elements and may be fastened together with any suitable means, such as an adhesive layer. The various elements of the digital camera **310** may be fabricated of any suitable material, such as plastic or metal. The moving parts of the gimbal **364** may be made of low friction materials to facilitate pivoting, or may be made of higher friction materials to dampen the pivoting action.

In another embodiment illustrated in FIGS. **6** and **7**, a digital camera **410** may comprise an optical system **444** mounted in a housing **442**. The optical system **444** is pivotally attached to the housing **442** with a ball and socket bracket **476**. An extension arm **480** is connected at one end to the housing **442**, while the other end is connected to a socket **479**. The socket **479** comprises a spherical interior sized to fit a ball **478**, allowing the ball **478** to fit within the interior and rotate without shifting. The bottom portion of the socket **479** is left open to allow a support arm **481** connected to the ball **478** to extend down from the ball **478**.

The size of the open bottom of the socket **479** may be varied by those skilled in the art according to several design considerations. The spherical interior of the socket **479** should remain just larger than a semi-sphere in order to hold the ball **478** in the socket, preventing the ball **478** from dropping out the bottom of the socket **479**. A large opening in the socket will allow the support arm **481** to swivel around larger angles, correcting for larger camera orientation angles. The size of the opening is preferably optimized to allow the ball **478** to be snapped into the socket **479** under pressure, but to prevent the ball **478** from falling out of the socket **479** under normal operating conditions.

The fit between the ball **478** and socket **479** may also be varied to vary the ease with which the optical system **444** may pivot. To dampen and slow the pivoting action, the fit between the ball **478** and socket **479** may be made relatively tight. To allow the optical system **444** to pivot more freely, the fit between the ball **478** and socket **479** may be made loose. Several considerations should be taken into account during design, such as weight of the optical system **444**, materials used in the ball **478** and socket **479**, the operating environment of the camera **410**, etc.

The housing **442** is sized to accept the optical system **444** and ball and socket bracket and to allow the optical system **444** to pivot or swing inside the housing **442**. The range of motion allowed the optical system **444** may vary according to the needs of the camera designer and manufacturer. For example, to correct only small errors in orientation, the housing **442** may be formed with little extra space for the optical system **444** to swing. Alternatively, to allow the optical system **444** to swing more freely to correct greater errors in orientation, a greater amount of extra space should be included between the optical system **444** and the housing **442**.

The digital camera **410** may also comprise a locking arm **474** which may pass through a hole **482** in the socket **479**. The locking arm **474** may then be pressed against the ball **478**, frictionally restricting its rotation in the socket **479** and locking the optical system **444** in place. The locking arm **474** may best be seen in FIG. **7** as it passes through the hole **482** in the socket **479**. The locking arm **474** may comprise a simple rod passing from the exterior of the housing **442** through the hole **482** in the socket **479**, allowing a user to press and hold the end of the locking arm **474**. Alternatively, a locking assembly (not shown) may be used to move the locking arm **474** between the locked and unlocked positions and to hold the locking arm **474** in place.

The digital camera **410** may also comprise an image sensor **460**, lens assembly (not shown), and other components mounted in the optical system **444** and in the housing **442** as needed.

Referring now to FIGS. **8**, **9**, and **10**, a digital camera may comprise a lock base **584** fixedly mounted inside the housing of the digital camera. An optical system **544** may be pivotally mounted below the lock base **584** with a gimbal bracket **585**, allowing the optical system **544** to pivot and swing inside the housing.

The gimbal bracket **585** may comprise a first gimbal arm **586** having a width substantially equal to the width of the lock base **584**. The first gimbal arm **586** may be pivotally mounted to the lower end of the lock base **584** on first gimbal supports **588**. A second gimbal arm **587** may be pivotally mounted at right angles to the first gimbal arm **586**, and the optical system **544** may be mounted below the second gimbal arm **587** on second gimbal supports **589**. As the camera is tilted, the housing (not shown), and the fixedly attached lock base **584** tilt along with it. The optical system **544** pivots on the gimbal bracket **585** to remain in a vertical orientation. The first gimbal arm **586** allows the optical system **544** to pivot along one axis, while the second gimbal arm **587** allows the optical system to pivot along another axis at right angles to the first, providing full motion around the long axis of the camera.

The gimbal elements may correspond to any known gimbal types or to any developed in the future. They may be designed with a stiff action to dampen oscillations in the optical system **544** relative to the housing, or may be left looser to facilitate pivoting. A separate dampening mechanism, such as a viscous fluid between moving parts, may also be included as desired.

The digital camera may also include a lock, comprising a slide ring **590** sized to fit over the lock base **584** and to slide up and down it. The slide ring **590** has at least one locking fingers **591** extending down from it, spaced to fit snugly around the sides of the optical system **544** when the lock is in the locked position. In a preferred embodiment, four locking fingers **591** extend down from the slide ring **590**, as seen from the bottom in FIG. **10**.

The at least one locking fingers **591** may alternatively engage in at least one hole (not shown) in the top of the optical system **544** to prevent the optical system **544** from pivoting.

When in the unlocked position (see FIG. **8**), the slide ring **590** is positioned near an upper end of the lock base **584**, and the attached locking fingers **591** lie alongside the lock base **584**. When in the locked position, the slide ring is slid down the lock base **584** to rest near a lower end of the lock base **584**, causing the locking fingers **591** to extend down between the gimbal arms **586** and **587** to fit around the sides of the optical system **544**, as illustrated in FIG. **9**. The optical system **544** is thereby held in position relative to the lock base **584** and to the housing, preventing it from pivoting under the force of gravity.

To move the slide ring **590** up and down the lock base **584**, a slide lever (not shown) may connect to the slide ring **590** and extend to the exterior of the camera housing, allowing a user to manipulate the slide ring **590**. The slide ring **590** is preferably sized to fit snugly over the lock base **584**, preventing it from inadvertently shifting.

Referring now to FIGS. **11** and **12**, another embodiment of a digital camera may comprise an optical system **644** mounted to a housing **642** by a gimbal bracket **685**. The gimbal bracket **685** may comprise a first gimbal arm **686**, pivotally attached at two ends to the housing **642**. A second gimbal arm **687** may be pivotally attached at right angles to the first gimbal arm **686** near a midpoint. The optical system **644** may be suspended below the second gimbal arm **687** by a pair of gimbal supports **689**. The optical system **644** may thereby pivot freely about the gimbal bracket **685** inside the housing **642**.

The digital camera may also comprise a lock mechanism, comprising at least one locking arms **691** spaced to fit around and engage with the sides of the optical system **644**. The locking arms **691** may be supported by a lock ring or disk **690** located above the optical system **644**. The lock ring is actuated by a plunger **692** which may be depressed to slide the locking arms **691** between the gimbal arms **686** and **687** and around the sides of the optical system **644**. To support and position the plunger **692**, a guide hole **693** may be located in a horizontal wall member **694** above the optical system **644**, allowing the plunger **692** to move up and down between the locked and unlocked positions without shifting from side to side.

In another embodiment illustrated in FIGS. **13**, **14**, and **15**, a digital camera may comprise an optical system **744** pivotally mounted to a housing **742** on a gimbal bracket **785**. The gimbal bracket **785** may comprise a first gimbal arm **786**, pivotally mounted at two ends to the housing **742** or another support member fixedly located within the housing **742**. A second gimbal arm **787** may be pivotally attached at right angles to the first gimbal arm **786**, allowing the gimbal bracket **785** two degrees of motion within the housing **742**. The optical system **744** may be suspended below the gimbal bracket **785** by a pair of gimbal supports **789** pivotally attached near the ends of the second gimbal arm **787**. As discussed previously, the housing **742** is large enough to leave empty space between the housing **742** and the optical system **744**, allowing the optical system **744** to freely pivot inside the housing **742**.

In an alternative embodiment, the optical system **744** may be pivotally mounted inside the housing **742** with one or more hinges (not shown), allowing the optical system **744** to pivot in one or more directions, depending upon the number of hinges used.

The digital camera may also comprise a locking ring cap **795**. The locking ring cap comprises a ring with a side wall **797** defining a center hole **796** through which image light may pass. The locking ring cap **795** may be placed around the lower end of the optical system **744** so that it fills the empty space between the optical system **744** and the housing **742** in at least three spaced apart locations, in order to prevent the optical system **744** from swinging in any direction within the housing **742**. When the locking ring cap **795** is placed upon the camera, optical light may pass through the center hole **796** in the cap **795** to reach the optical system **744**.

The locking ring cap **795** is preferably sized to fit snugly between the optical system **744** and the housing **742** so that it prevents pivoting and so that it will not fall off of the optical system **744** if jarred or bumped. Alternatively, corresponding ridges and valleys in the ring cap **795** and the optical system **744** or housing **742** may engage when the cap **795** is in the locking position, preventing the cap **795** from inadvertently falling from the camera. The side wall **797** of the locking ring cap **795** may also be beveled near the top to facilitate insertion around the optical system **744**.

The locking rings and cap disclosed herein have the advantage of centering the optical system within the housing, simplifying image composition, and providing positive engagement to securely lock the optical system in place. The frictional locking arms, in contrast, may lock the optical system at any desired angle, but do not provide positive engagement, thus provide a less secure lock.

While presently preferred illustrative and exemplary methods of pivotally mounting the optical system (e.g., **44**) in a camera housing (e.g., **42**) have been disclosed, the optical system **44** may be mounted in the housing **42** with any suitable pivoting bracket now known, or which may be developed in the future, without departing from the inven-

tive concepts disclosed herein. Therefore, the gimbal optical system for document image capture should not be regarded as limited to the brackets described in detail. It is to be understood that the inventive concepts may be otherwise variously embodied and employed, and that the appended claims are intended to be construed to include such variations, except as limited by the prior art.

What is claimed is:

1. An imaging device for document imaging, comprising:

a body portion;

an optical assembly;

a pivotal mounting bracket, whereby said optical assembly is pivotally mounted to said body portion; and

a lock having a locked position and an unlocked position, whereby said optical assembly may be locked into place relative to said body portion when said lock is in said locked position, and where said optical assembly may pivot about said pivotal mounting bracket when said lock is in said unlocked position, wherein said lock comprises at least one locking fingers operatively associated with said body portion, said at least one locking fingers engaging with said optical assembly when said lock is in said locked position to hold said optical assembly in place relative to said body portion.

2. An imaging device for document imaging, comprising:

a body portion;

an optical assembly;

a pivotal mounting bracket, whereby said optical assembly is pivotally mounted to said body portion; and

a lock having a locked position and an unlocked position, whereby said optical assembly may be locked into place relative to said body portion when said lock is in said locked position, and where said optical assembly may pivot about said pivotal mounting bracket when said lock is in said unlocked position, wherein said pivotal mounting bracket comprises a gimbal, and wherein said lock comprises a ring cap comprising a ring which may be slid around said optical assembly to rest between said optical assembly and said body portion, preventing said optical assembly from moving relative to said body portion.

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